The Anoka County Pavement Management System

LIFE CYCLE COST ANALYSIS

ANALYSIS OVERVIEW

There are two parts to the Life Cycle Cost (LCC) Analysis, Unit Costs and Life Cycle Curves. This document will discuss how the two parts of the system are derived and how the system uses the values produced by it to determine an ordered list of recommendations for future rehabilitation projects.

UNIT COSTS

The table below contains costs and area data related to past rehabilitation projects. Unit costs are figured from these projects to reflect the cost of the final paved square footage (Total Cost/Finished Paved SQFT Area) for a selected strategy. Strategies being: Simple Overlay, Mill and Overlay, and Reclaim and Overlay.

In most cases the highest cost value has been used, and due to the wide range of variability an inflation factor has not been used.

COST ANALYSIS

PROJECT	TYPE	AREA	COST	UNIT COST		AVERAGE / YEAR	
13-13-13	Reclaim and Overlay	270024	$628,756	$2.33			
13-14-15	Simple Overlay	439265	$393,107	$0.89		RECLAIM	$2.28
13-15-18	Reclaim and Overlay	372564	$755,938	$2.03	2013	MILL	$1.29
13-17-34	Reclaim and Overlay	99387	$247,454	$2.49		OVERLAY	$0.89
13-18-18	Mill and Overlay	218414	$280,835	$1.29			
11-11-11	Mill and Overlay	229059	$282,179	$1.23			
11-12-14	Reclaim and Overlay	254529	$503,731	$1.98			
11-13-16	Simple Overlay	262586	$265,161	$1.01			
11-16-22	Reclaim and Overlay	628515	$1,016,494	$1.62			
11-17-24	Reclaim and Overlay	259878	$616,425	$2.37			
11-19-53	Simple Overlay	142745	$135,045	$0.95		RECLAIM	$1.98
11-25-85	Reclaim and Overlay	651753	$1,174,358	$1.80	2012	MILL	$1.26
12-10-01	Mill and Overlay	315072	$405,848	$1.29		OVERLAY	$0.98
12-12-20	Reclaim and Overlay	200687	$441,105	$2.20			
12-13-21	Reclaim and Overlay	225210	$474,408	$2.11			
12-15-62	Reclaim and Overlay	753903	$1,251,552	$1.66			
12-16-66	Reclaim and Overlay	267507	$566,886	$2.12			
11-14-18	Reclaim and Overlay	649926	$943,295	$1.45			
11-18-36	Simple Overlay	355114	$330,936	$0.93			
11-20-54	Simple Overlay	457063	$440,982	$0.96		RECLAIM	$1.59
11-21-54	Reclaim and Overlay	477153	$731,849	$1.53	2011	MILL	$1.31
11-23-67	Simple Overlay	201295	$207,684	$1.03		OVERLAY	$0.98
11-26-01	Mill and Overlay	118656	$155,751	$1.31			
11-27-20	Reclaim and Overlay	361539	$646,146	$1.79			
10-12-08	Mill and Overlay	42831	$58,084	$1.36			
10-13-11	Mill and Overlay	190800	$186,561	$0.98			
10-14-116	Mill and Overlay	77994	$146,320	$1.88			
10-15-02	Mill and Overlay	80217	$86,438	$1.08			
10-16-08	Mill and Overlay	127728	$91,552	$0.72		RECLAIM	$2.20
10-17-17	Simple Overlay	502022	$425,750	$0.85	2010	MILL	$1.16
10-18-24	Reclaim and Overlay	49086	$120,328	$2.45		OVERLAY	$0.87
10-19-54	Reclaim and Overlay	525204	$1,028,294	$1.96			
10-21-86	Reclaim and Overlay	368316	$808,671	$2.20			
10-22-18	Simple Overlay	129780	$114,508	$0.88			
10-23-01	Mill and Overlay	188019	$174,388	$0.93			

UNIT COST: **Cost / SqFt of Finished Paved Area**

AVERAGE OF ALL		FINAL	
RECLAIM	$2.00	**$2.15**	Average Highest Value and Overall Average
MILL	$1.25	**$1.31**	Highest Value
OVERLAY	$0.94	**$0.98**	Highest Value

LIFE CYCLE CURVES

Life cycle performance curves are generated from rating data and historical project information. All of the road segments on the network are grouped based on traffic volume ranges and the last project performed, this reduces the amount of curves needed. It is assumed that the roads with similar traffic volumes and construction strategies deteriorate at about the same rate. A trend line is fit to a scatter plot of road ratings over time for specific classifications of roadways (see Curve Fitting Example). The max life value might seem large but keep in mind that the road would actually be considered for repair around a PQI of 40-50. Looking at the life values in this way shows a Reclaim lasts around 35 – 40 years, a Mill lasts around 15 years, and a Simple Overlay lasts around 20 years.

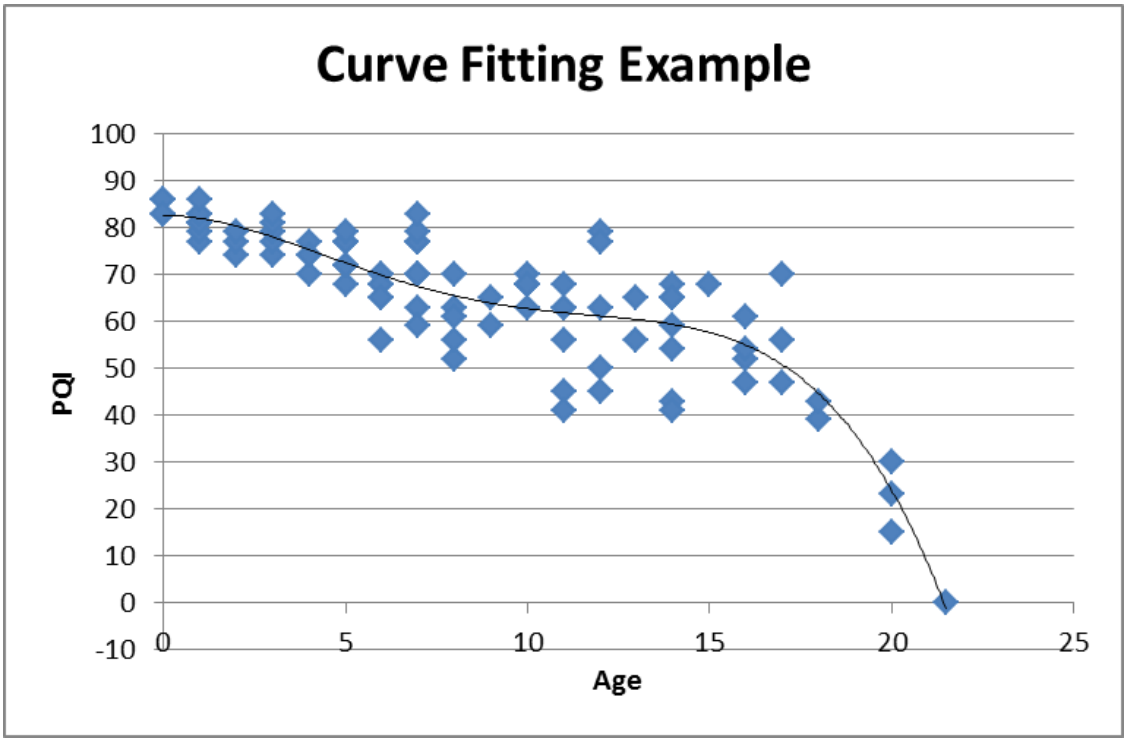
All the current individual curves can be found on the next few pages, both a graphic and the formula are given.

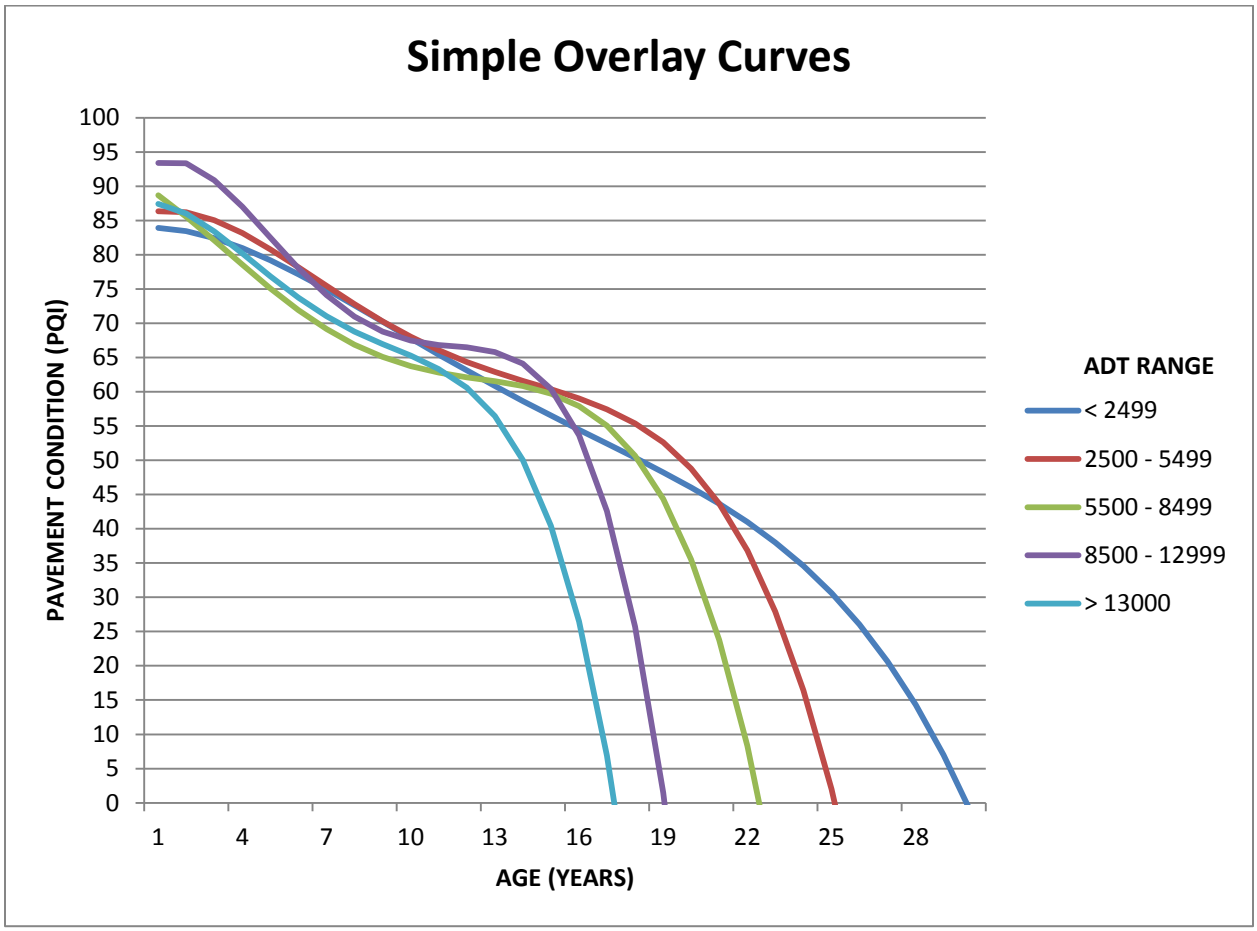
The formula takes this form: $Y = A + BX + CX^2 + DX^3 + EX^4$

Y = PQI

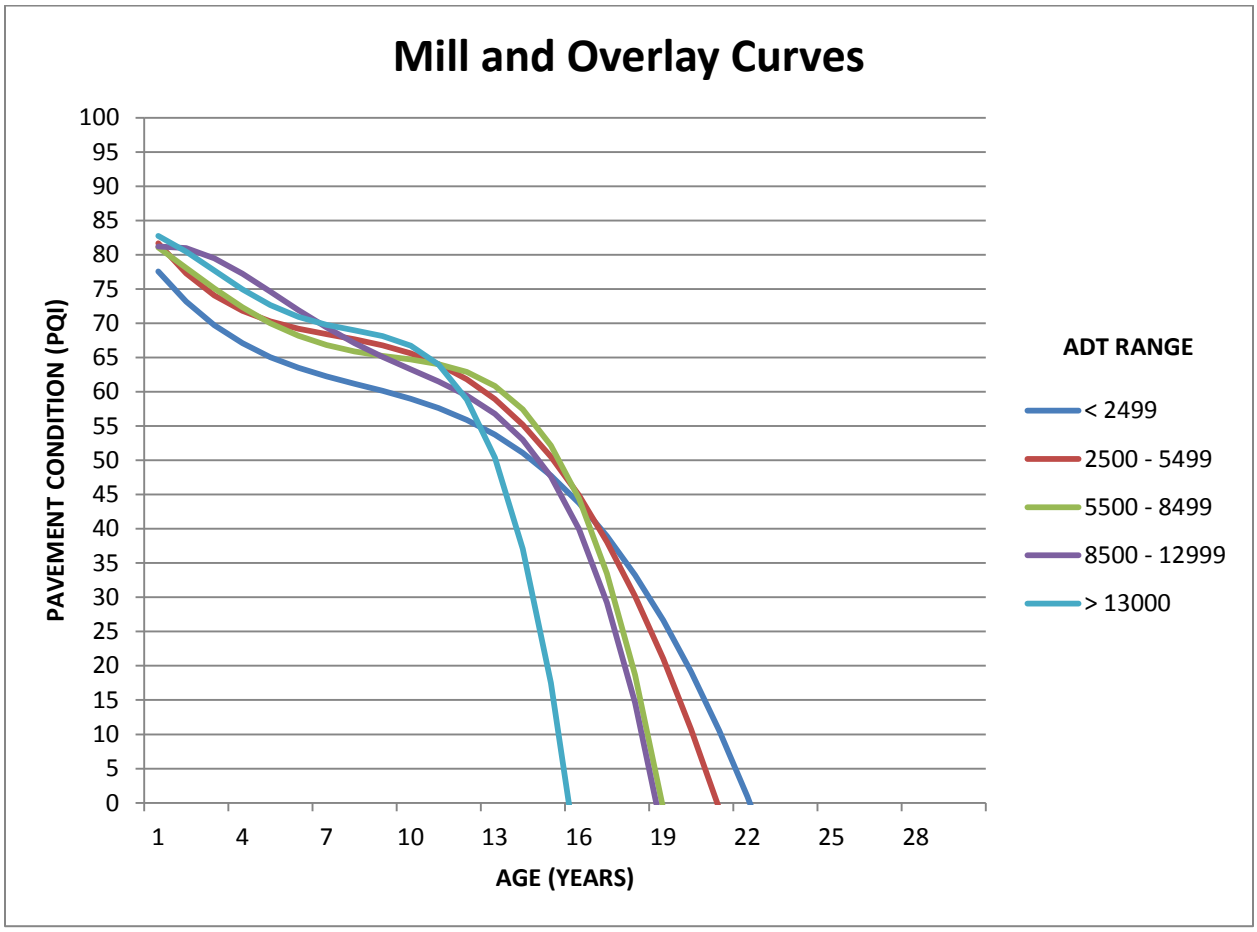
X = AGE

CURVE FACTORS = A, B, C, D, & E

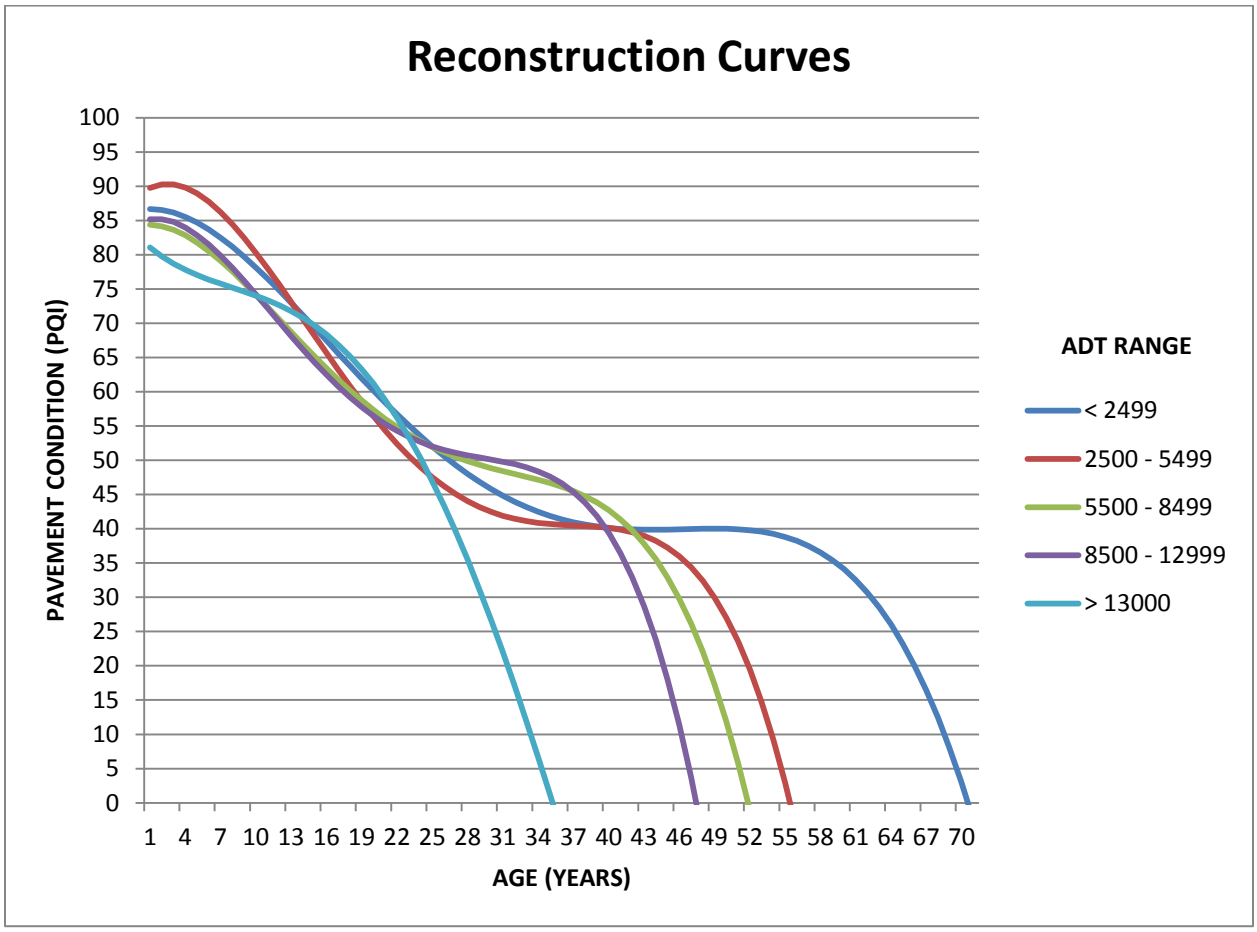




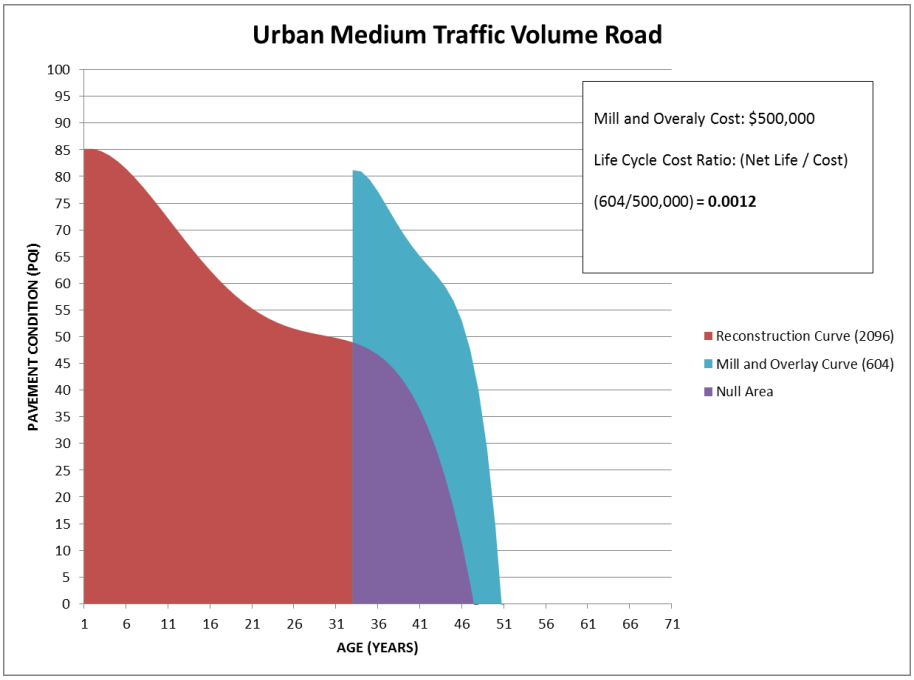
Curve Formula and Life Values								
CURVE	RANGE	A	B*X	C*X^2	D*X^3	E*X^4	MAX LIFE (L)	MAX LIFE (A)
Simple Overlay	< 2500	83.895911891	-0.154193518	-0.329601350	0.020255248	-0.000421120	28.82	1542.74
Simple Overlay	2500 TO 5500	86.336727564	0.485378972	-0.671150880	0.056956103	-0.001497302	24.12	1459.01
Simple Overlay	5500 TO 8500	88.669513583	-2.821436937	-0.334849383	0.055967396	-0.002014388	21.45	1283.91
Simple Overlay	8500 TO 13000	93.403765335	1.545264164	-1.790515435	0.209653057	-0.007261943	18.05	1208.62
Simple Overlay	> 13000	87.406796733	-0.503931478	-1.004957159	0.141982455	-0.006053453	16.29	1019.66



Curve Formula and Life Values								
CURVE	RANGE	A	B*X	C*X^2	D*X^3	E*X^4	MAX LIFE (L)	MAX LIFE (A)
Mill and Overlay	< 2500	77.559504619	-4.935608987	0.571713825	-0.030920852	0.000314823	21.09	1059.14
Mill and Overlay	2500 TO 5500	81.677261185	-5.084600431	0.733001527	-0.045964026	0.000585516	19.93	1107.49
Mill and Overlay	5500 TO 8500	81.086998254	-2.965299321	-0.114664155	0.052326038	-0.002825194	17.96	1061.86
Mill and Overlay	8500 TO 13000	81.197651462	0.581155227	-0.918163157	0.106101474	-0.003980086	17.77	1051.74
Mill and Overlay	> 13000	82.762010770	-1.811868437	-0.604926761	0.137674263	-0.007785951	14.67	918.62

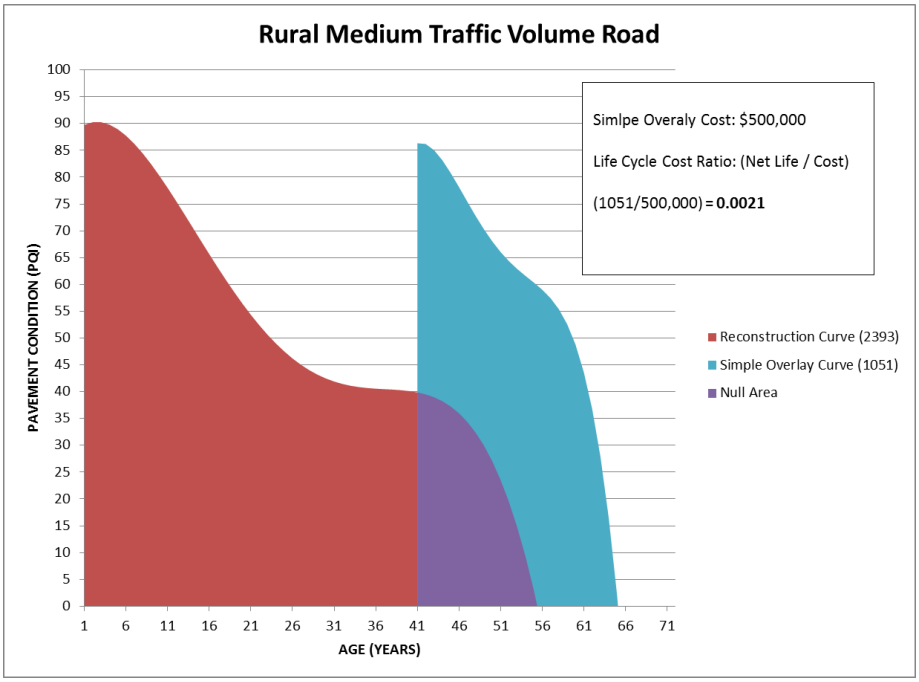


Curve Formula and Life Values								
CURVE	RANGE	A	B*X	C*X^2	D*X^3	E*X^4	MAX LIFE (L)	MAX LIFE (A)
Reconstruction	< 2500	86.685558610	-0.006698207	-0.138983404	0.004112242	-0.000034079	69.55	3390.13
Reconstruction	2500 TO 5500	89.760484736	0.782957465	-0.284365629	0.009824091	-0.000099591	54.43	2801.43
Reconstruction	5500 TO 8500	84.372373858	-0.030625296	-0.182575842	0.007417446	-0.000087647	50.85	2687.33
Reconstruction	8500 TO 13000	85.174083166	0.267586896	-0.253899656	0.011165537	-0.000143667	46.45	2544.40
Reconstruction	> 13000	81.051376790	-1.413752968	0.130259859	-0.007363546	0.000080135	34.22	1913.46



Current Proposed Strategy Parameters:

Excluded Segments	HIP Roads, PQI > 70, AGE < 10
Mill and Overlay	Urban Road
Reclaim and Overlay	AADT > 2500 & Geometric Rating > 40
Simple Overlay	AADT < 2500 & Geometric Rating < 40

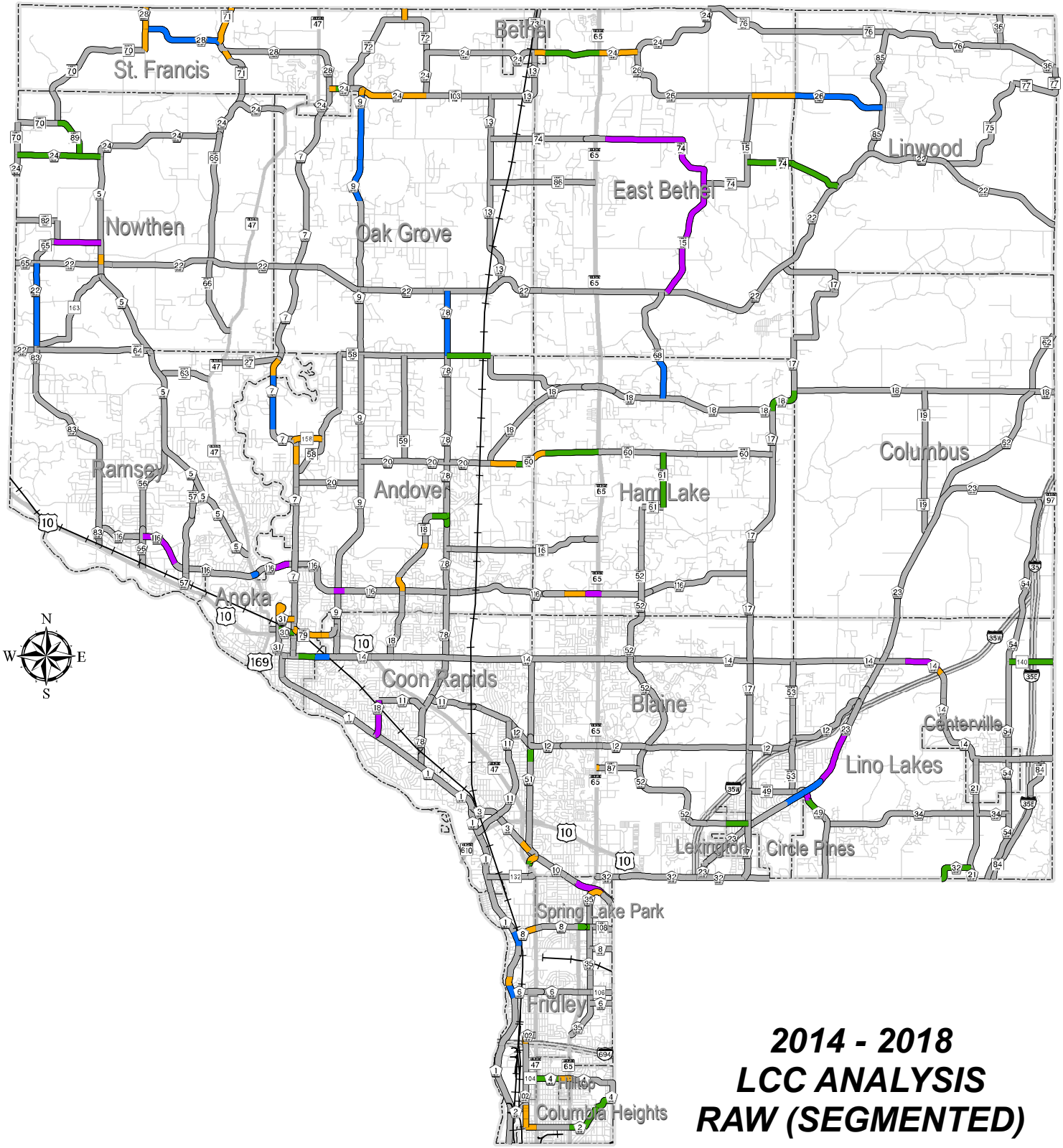


LIFE CYCLE COST ANALYSIS

The analysis process compares each road segment together at its current age. Along the initial strategy curve (shown in red), a proposed strategy is applied (shown in blue). The program calculates the area shown in blue, which is an arbitrary value describing the segments life improvement. The graphs show two different segments of roads that have the same repair cost; in this case the program will select the rural segment over the urban segment because the life extension is greater.

There are currently over 500 segments on the network that vary in age, area, and cost, meaning over 500 different variations of the 15 curves are applied to each other during the first part of the analysis. The segments are then arranged with the greater Life/Cost ratio on the top on the list, meaning the higher the value on the segment more benefit we get repairing it relative to lower valued segments. In summary it allows us to locate what segment of roadway to repair at the optimum time for the least amount of cost providing the largest life extension.

After all the segments have been compared to each other there are inevitable inconsistencies between adjoining segments, meaning segments right next to each other are chosen for repair on different years. Using a manual process the segments are adjusted using the ratios. The following two maps show the results of the “Raw” verses the “Adjusted” analysis.



2014 - 2018 LCC ANALYSIS RAW (SEGMENTED)

Road Type

- 2015 LCC ANALYSIS
- 2016 LCC ANALYSIS
- 2017 LCC ANALYSIS
- 2018 LCC ANALYSIS

LCC: LIFE CYCLE COST

- COUNTY ROAD
- CSAH
- STATE HIGHWAY
- US HIGHWAY
- INTERSTATE

Map Document: (T:\Pavement Management System\Data\SEGMENT_INVENTORY\2014\ANALYSIS REPORT\LCC_RAW(SEGMENTED).mxd)
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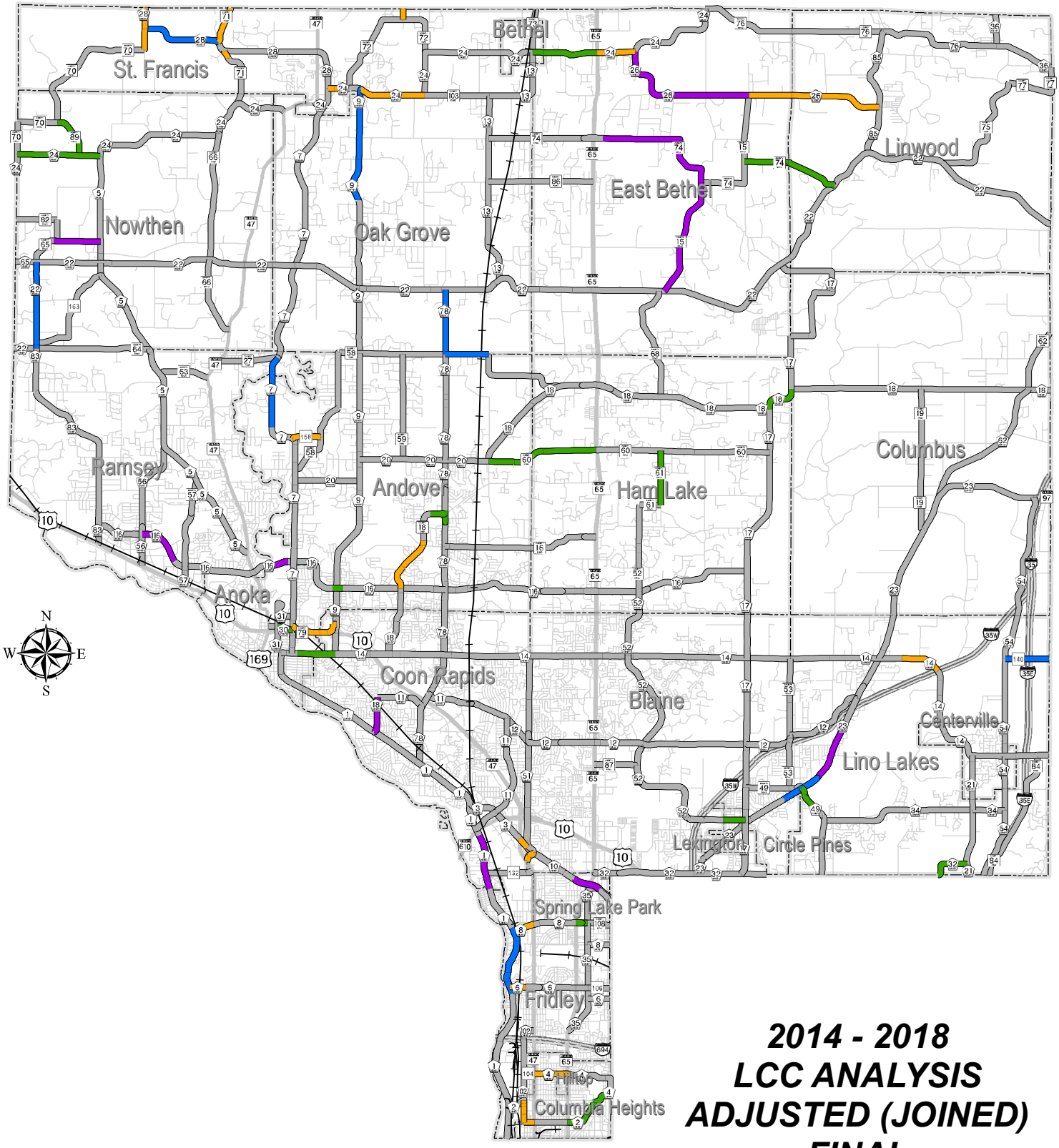

2014 - 2018 LCC ANALYSIS ADJUSTED (JOINED) FINAL

Road Type

- 2015 LCC ANALYSIS
- 2016 LCC ANALYSIS
- 2017 LCC ANALYSIS
- 2018 LCC ANALYSIS

LCC: LIFE CYCLE COST

- COUNTY ROAD
- CSAH
- STATE HIGHWAY
- US HIGHWAY
- INTERSTATE

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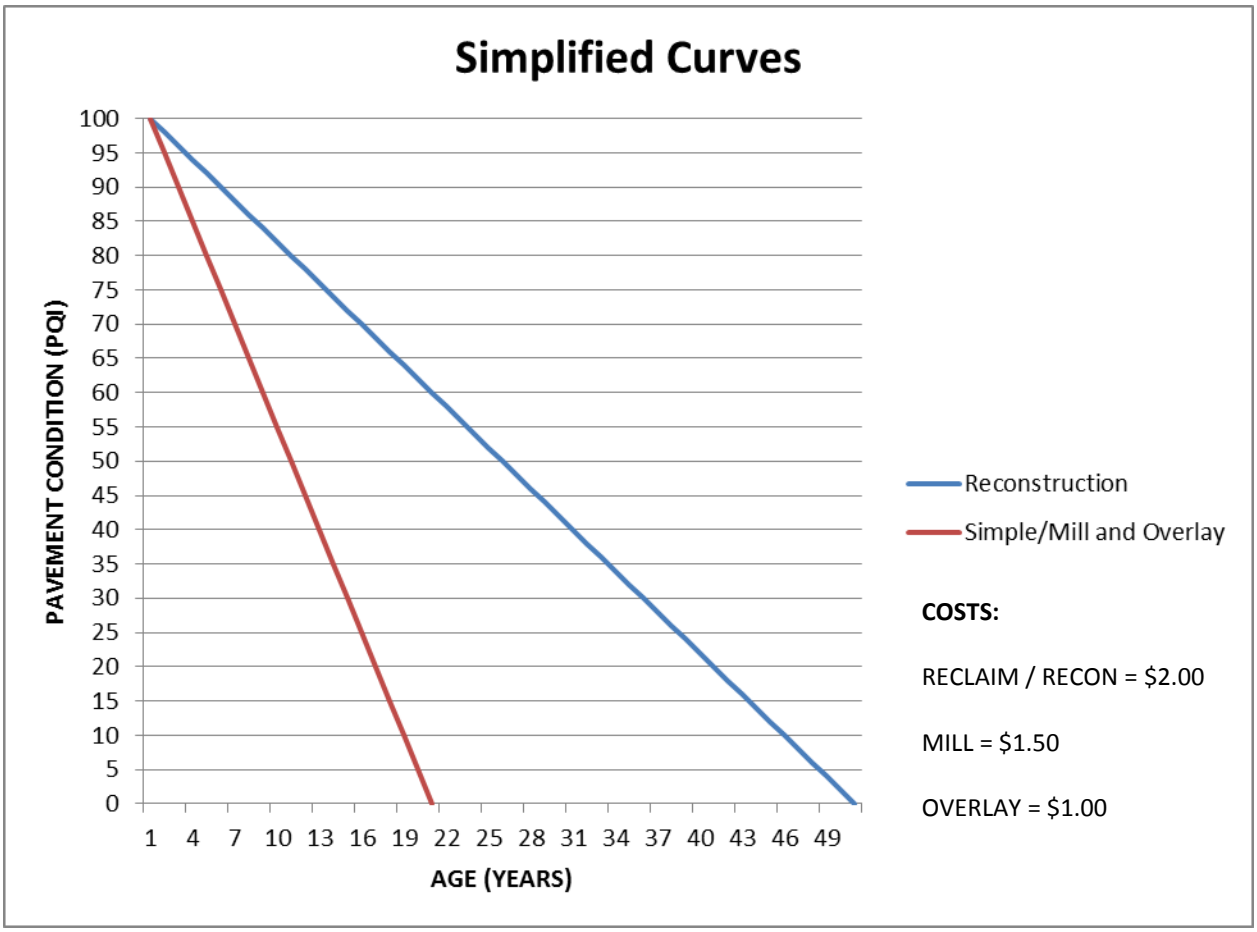


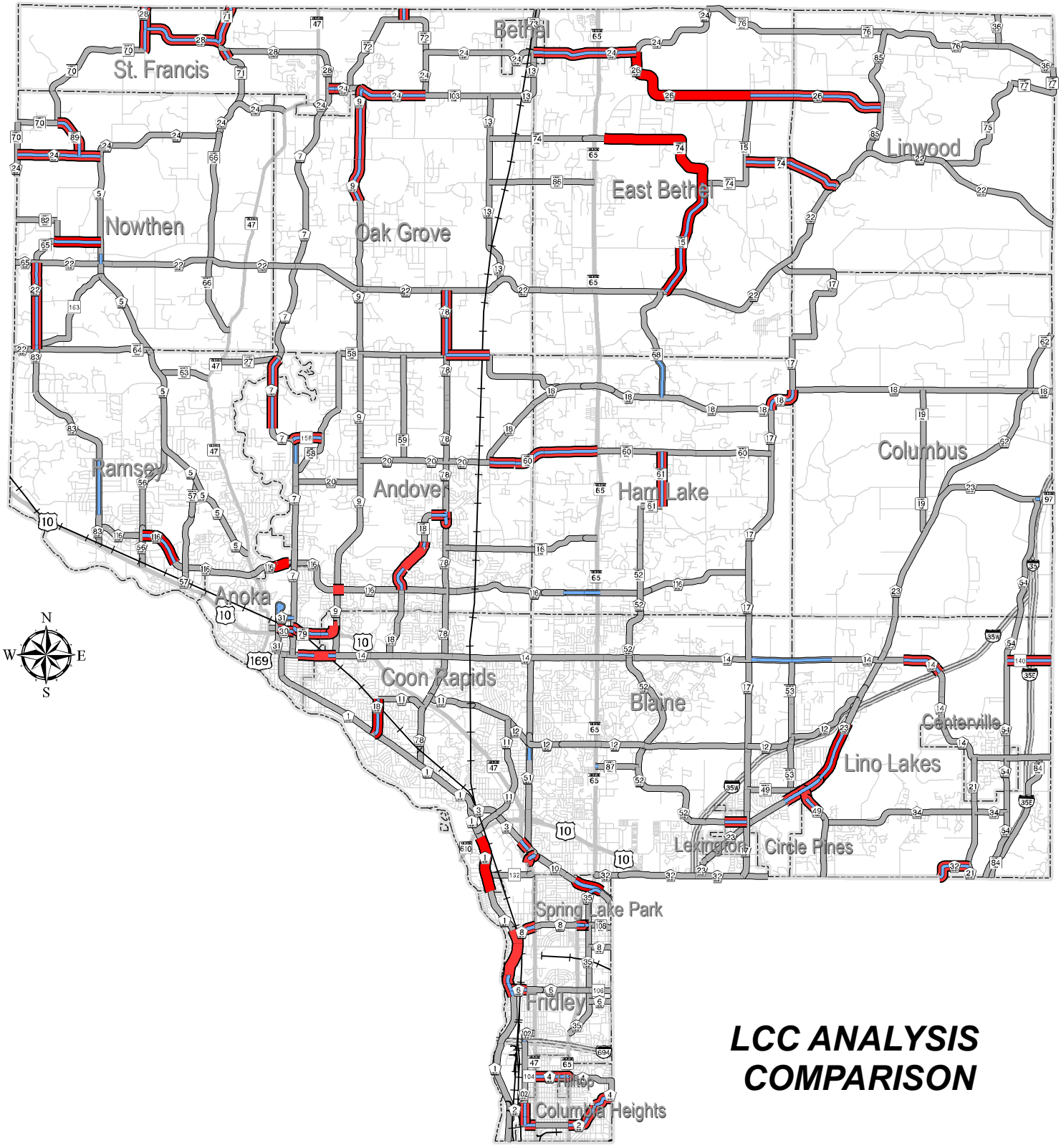
SIMPLIFIED ANALYSIS

A simplified analysis was performed as a benchmark to see how it behaved with simplified life cycle curves and costs applied throughout the network, the simplified curves and costs are shown in the graphic above. The map on the following page shows the results of the 2014 Life Cycle Cost Analysis (Standard Analysis) compared to the Simplified Analysis grouped over a period of four years.

The results show segments from the Simplified Analysis coincide with the Standard Analysis 78% of the time, with 89% of the segments in the first year.

One can see that as long as relative parameters are maintained the analysis will perform roughly the same. More specifically as long as the costs reflect a difference between the strategies (Reclaims are more than Mills which are more than Overlays), and the curves reflect a difference in life (Reclaims last longer than Mills and Overlays) the analysis can still produce meaningful results despite the costs varying by as much as $0.20 and the life, or curves, varying by as much as 15 years.

The Standard Analysis should obviously be considered more accurate, and will continue to be successively more accurate over time as new data is annually added to the system.



LCC ANALYSIS COMPARISON

LCC SIMPLIFIED ANALYSIS
LCC ANALYSIS

LCC: LIFE CYCLE COST

COUNTY ROAD
CSAH
STATE HIGHWAY
US HIGHWAY
INTERSTATE

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Prepared by Anoka County Highway Department

INVENTORY

The Pavement Management System performs the pavement modeling analysis explained above based on inventoried data. The other main use of the system is this inventory for the purpose of basic inquiry. This data can be viewed on our internal interactive map. The table below shows some of the data available within the segments layer of the map.

FROM
TO
STREET NAME
ROUTE
CITY
DISTRICT
LANES
LENGTH (FT)
WIDTH LANES
LENGTH (MI)
LANE MILES
WIDTH SHLDRS
WIDTH
AREA
TURN LANE COUNT
BYPASS COUNT
GEO RATING
SECTION THICKNESS / TYPE
TON FWD
NON PLASTIC
ORGANIC
PLASTIC
LAST PROJECT NUMBER
CONSTRUCTION AGE
PAVEMENT AGE
LAST PROJECT
LAST PROJECT DATE
LAST RECONSTRUCTION
LINKS TO PLANS
CURRENT PQI
CAPACITY
CURRENT AADT
PROJECTED AADT
HIP ROADS AND COSTS
PLOW ROUTES